The Impact of Seal Leakage flow on the Performance of Multi-stage Axial Flow Compressors

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To enhance the performance of multi-stage axial flow compressors beyond today's machines, it is becoming increasingly clear that the impact of under-platform seal leakage flow on the primary passage flow stream must be understood at a more fundamental level than exists today. Furthermore, analytical or semi-empirical models must be developed to account for the effect of under-platform leakage in CFD simulation codes so that these leakages are accounted for in numerical simulations. Finally, based on the results obtained from research studies, information must be drawn as to how to manage these leakage flows so as to minimize their impact on performance and, if possible, enhance performance.

The number of published works which show the impact of under-platform leakage flow on compressor performance is not extensive. Recently a very comprehensive investigation of the impact of under-platform stator hub leakage flow on the primary passage flow of a low speed compressor by Wellborn (1996) showed that the effect of the leakage extended over the entire flow annulus. The recent numerical and experimental study by Shabbir et. al. (1997) showed the same was true for a high speed axial flow compressor rotor. The conclusions drawn by Shabbir et. al. state that: (1) the addition of hub leakage flow to the primary passage flow can reduce the pressure rise capability of a high speed rotor; (2) hub leakage flow not only results in the formation of a near-hub deficit in total pressure but also causes a reduction in the pressure rise over the entire span of the rotor; and (3) the reduction in pressure rise is caused by blockage changes due to the leakage. Finally, this paper showed that a hub leakage of 0.25% of the incoming mass flow resulted in nearly a 1.5% reduction of the pressure ratio relative to the no leakage result. At the same operating point a 0.25% change in the primary passage flow would reduce the total pressure ratio by only 0.2% which is nearly an order of magnitude less than that due to leakage. The impact of the leakage flow on pressure ratio is therefore very large.

In closing, a great deal of effort is being spent in the development of CFD codes for simulating multi-stage axial flow turbomachinery (compressors and turbines). One of the major issues faced by the developers of these codes is accounting for the effect of under-platform leakage on the primary passage flow stream. The straight forward CFD approach of gridding up the under-platform flow region as part of the entire passage flow simulation would result in simulations whose computing requirements would be impractical for use in design. What is needed are analytical or semi-empirical models by which the impact of the under-platform leakage flow can be accounted for in the simulation of the primary passage flow.

REFERENCES

Shabbir, A., Celestina, M. L., Adamczyk, J. J., and Strazisar, A. J., 1997, "The Effect of Hub Leakage Flow on Two High Speed Axial Flow Compressor Rotors", ASME Paper No. 97-GT-346

Wellborn, S., 1996, "Effects of Shrouded Stator Cavity Flows on Multistage Axial Compressor Aerodynamic Performance", NASA CR 198536.

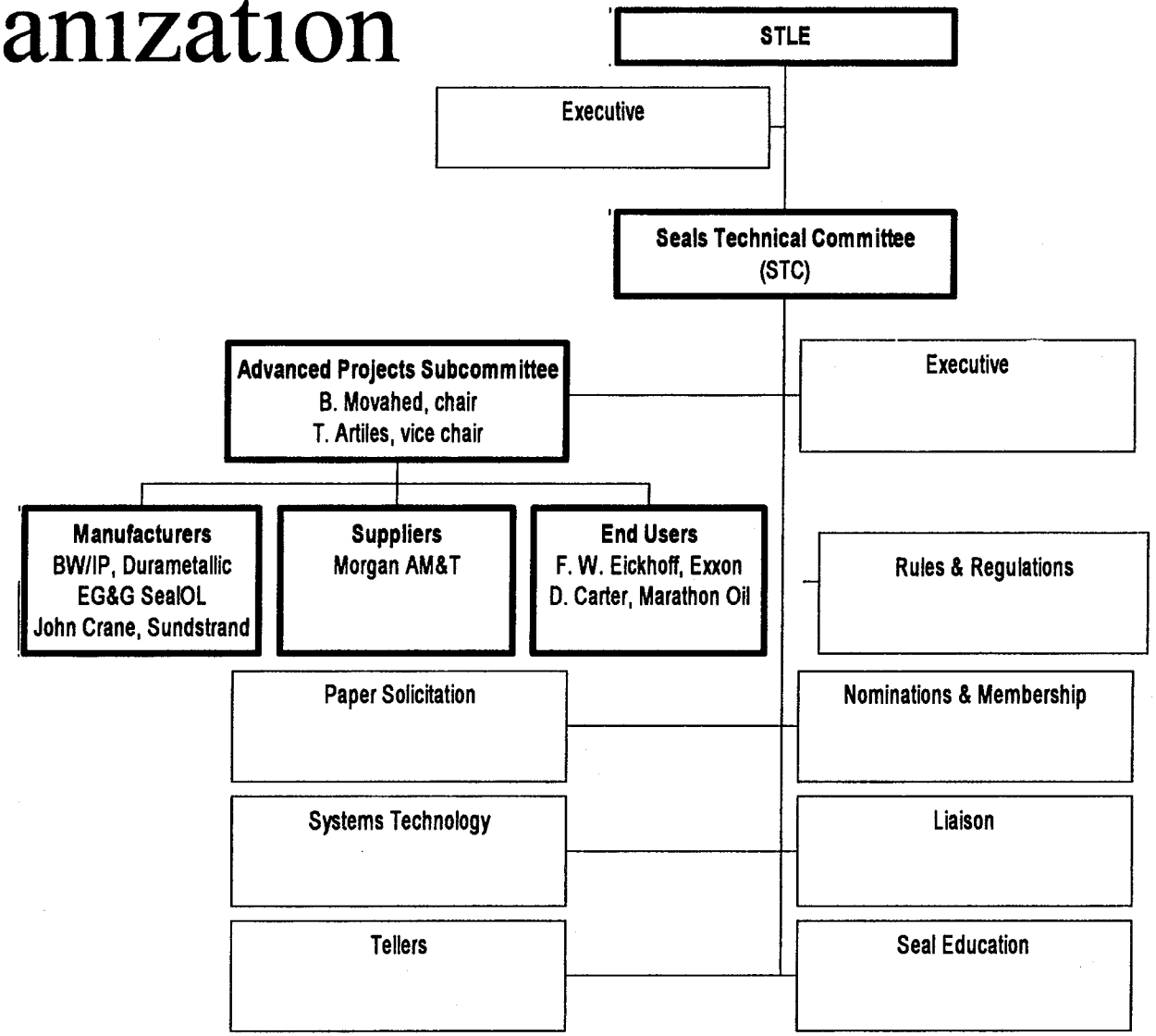
ADVANCED PROJECTS SUBCOMMITTEE OF THE SEALS TECHNICAL COMMITTEE (STC)

Tony Artiles
Society of Tribologists and
Lubrication Engineers

Overview

- Organization
- Function, Foundation and Charter
- Independent seal researchers
- Qualified research proposals
- Ground rules
- Minimum proposal content
- Time line: 2 year cycle
- Projects to Date
- Program Sponsors
- Current priorities for research
- Key Benefits & Future
- Submission Process, Selection Process

Organization



Function

Recognized the need for joint sponsorship of research projects on seals, sealing systems, and sealing devices

- In view of the ever-shrinking funding from government & industry, at the Oct. 1988 ASME/STLE Conference, the APS was formed to:
- **Solicit research proposals** from independent seal researchers
- **Select and award** a research project
- **Solicit and allocate** funding from sponsors

Independent seal researchers

- University scientists, or
- Non-university seal experts
- Not affiliated with commercial producers of:
  - **seals,**
  - **sealing systems, and**
  - **sealing devices**

Qualified research proposals

- Publishable
- Sufficiently generic so no competitive concerns among sponsors
- Basic research
- Of widest interest to sealing community
- New & previously unreported investigations on the fundamental understanding of:
  - **seals,**
  - **sealing systems, and**
  - **sealing devices**

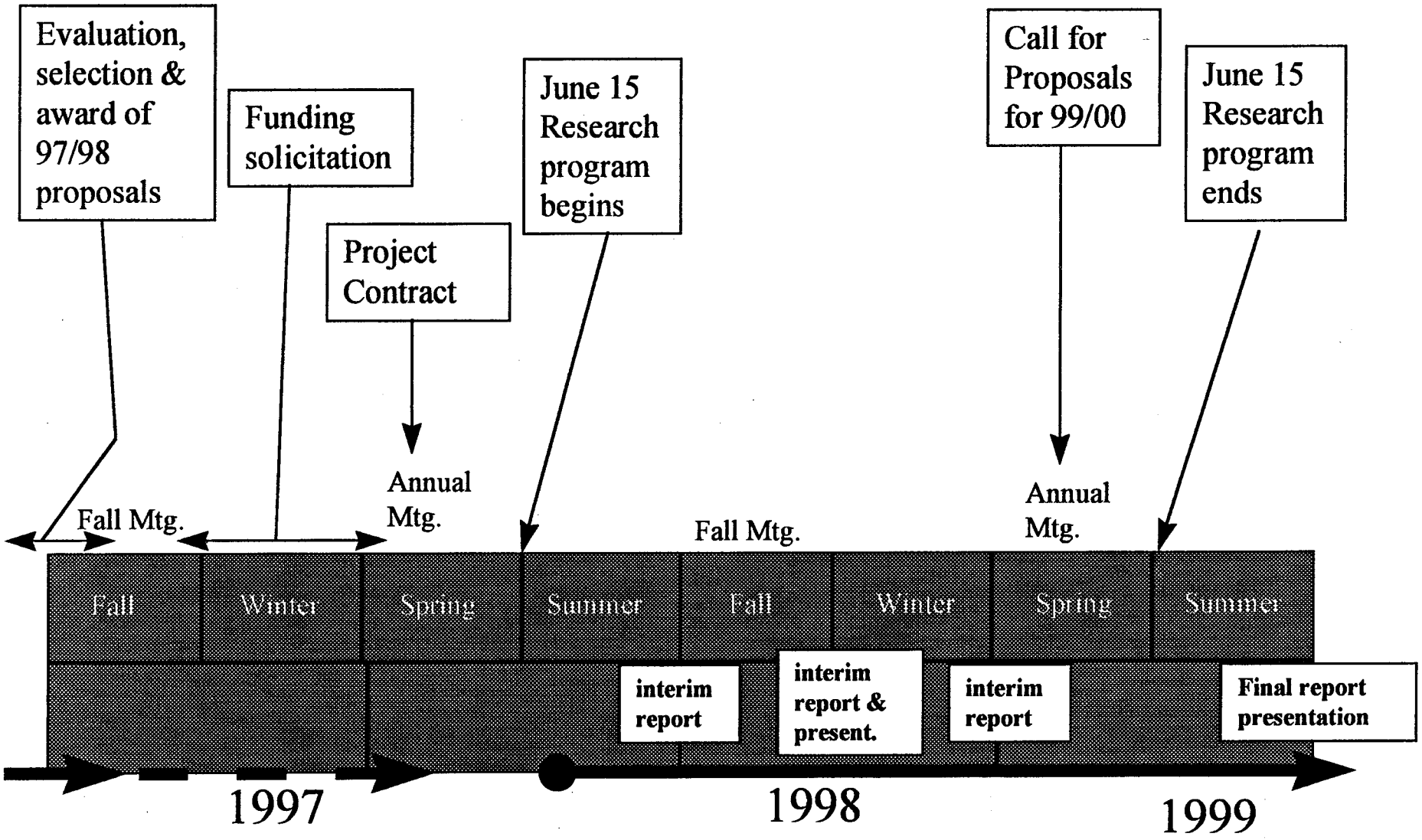
Ground rules:

- Reports & software accessible to sponsors only (not APS or STC)
- Software licence 5 yr.
- Paper submitted to STLE journal 2 years after final payment
- Funds managed by APS chair & STC treasurer.
- 20% withholding pending approval by majority of sponsors
- English
- APS members not required to fund

Minimum proposal content:

- Summary
- Objective
- Background Qualifications
- Scope
- Specific Deliverables
- Schedule
- Budget and Payment Schedule
- Personnel
- Facilities
- Conflict of Interest Waiver Format

Time line: 2 year cycle



Research Projects to Date

Project / Sponsors		Cost total (each)	Title	Researcher(s)	Institution	Time frame
1	10	$49,400 ($4,900)	Static Sealing Performance of End Face Seals	Dr. I. Etsion	Technion Institute	1990-1992
2	8	$63,800 ($7,975)	Sealed Fluid Temperature and Film Coefficient Prediction and Measurement	Drs. A. LeBeck & S. Shirazi	MSTI and University of Tulsa	1992-1994
3	14	$70,000 ($5,000)	Experimental & Analytical Investigation of Blistering in Carbon/Graphite Seal Materials	Drs. P. Guichelaar, P. Merati & M. Williams	Western Michigan University	1994-1996

Program Sponsors

Project No. 1	Project No. 2	Project No. 3
ACI Coors Ceramics Co.	A. W. Chesterton	A. W. Chesterton
Atomic Energy of Canada - AECL	BW/IP International Inc.	BW/IP International Inc.
BW/IP International Inc.	Carbon Technology Inc.	CTI Inc.
Carbon Technology Inc.	Durametallic Corporation	Durametallic Corporation
Durametallic Corporation	EG&G Sealol, EPD	EG&G Sealol, EPD
Eagle Industry, Ltd.	Exxon Research & Engineering	Exxon Research & Engineering
EG&G FCTG Sealol, Inc.	Fedor Burgmann GMBH	Fedor Burgmann GMBH
Exxon Research & Engineering	John Crane Inc.	John Crane Inc.
FL Aerospace Corporation		Rexnord Corporation Seal Oper.
U. S. Graphite, Inc.		Carbone Lorraine
		Deublin Company
		ROC Carbon Company
		U.S. Graphite, Inc.
		UTEX Industries, In